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Strategies for renewable energy applications in the organization of Islamic conference (OIC) countries

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ABSTRACT

Presently, the demand of energy is met by fossil fuels. Combustion of fossil fuels has caused negative impacts to the environment globally. The most significant ones are acid precipitation, stratospheric ozone depletion, and global climate change. To overcome it, sustainable, clean and safe energy policies that would satisfy the energy demand of the 21st century have to be implemented. Renewable energy resources appear to be the one of the most efficient and effective solutions, therefore be key energy sources for the future. There is an intimate connection between renewable energy and sustainable development. Current status of renewable energy applications, its implementation strategies and their obstacles for some of the selected Islamic countries has been presented. Several strategies for enhancing of widespread application of renewable energy technology are described. The strategies include establishing education and capacity building programs, creating renewable energy market and financing mechanism, improving appropriate energy policies and establishing database and international collaboration to promote renewable energy technologies.

Contents

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1. Introduction

Energy is a key factor in economic development and in providing vital services that improve quality of life. Energy is required for meeting all of the basic needs such as food and health, agriculture, education, information, and other infrastructure services and shows clear correlation with the Human Development Index HDI (see Fig. 1) [1]. There are wide variations in energy consumption between developed and developing countries, and between the rich and the poor, with attendant variations in human development. Furthermore, the way in which energy is generated, distributed and consumed affects the local, regional and global environment with serious implications for poor people's livelihood strategies and human development prospects [2].

Sustainable development demands a sustainable supply of energy resources that, in the long term, is readily and sustainably available at reasonable cost and can be utilized for all required tasks without causing negative societal impacts. Supplies of energy resources such as fossil fuels (coal, oil, and natural gas) and uranium are generally acknowledged to be finite; other energy sources such as solar, wind and hydro are generally considered renewable and therefore sustainable over the relatively long term [3]. Fig. 2 shows the schematic of sustainable development.

Until today, the demand of energy is met by fossil fuels (i.e. coal petroleum and natural gas). It is a well know fact that 8 countries have 81% of all world crude oil reserves, 6 countries have 70% of all natural gas reserves and 8 countries have 89% of all cost reserves [4]. More than half of Asia, Africa and Latin America import over half of all their commercial energy. This problem is worsened by the fact that demand on power generation is continuously increasing in these countries.

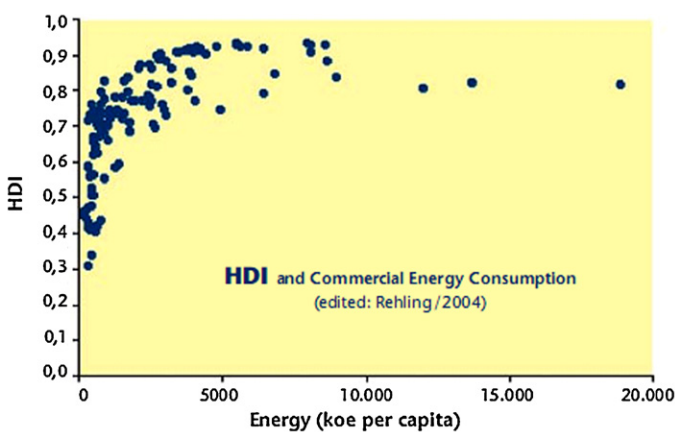

Fig. 1. HDI and commercial energy consumption.

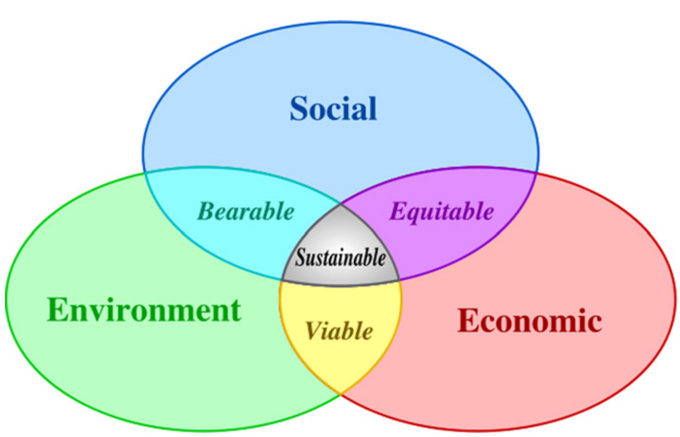

Fig. 2. Elements of sustainable development.

The world faces an unsustainable energy future if governments do not radically change their energy policies by 2020. If governments stick with current policies, the world's primary energy needs will grow by 55% between 2005 and 2030. Growing demand will happen mostly in developing countries and will be overwhelmingly (84%) met by fossil fuels. Greenhouse gas emissions will rise by 57% [26a].

It is estimated that 16 million tones of CO_2 are emitted into the atmosphere every 24 h worldwide. If all emissions were to stop today, the CO_2 that has already been emitted will result in an enhanced GHG effect for the next 50 years. Meeting the energy needs of un-served populations in developing countries while at the same mitigating climate change is a major challenge and requires a number of government actions and international cooperation in promoting renewable energy, enacting proper regulations, attracting sufficient investment in clean energy development, reworking the tax structure to remove barriers to energy access, as well as effective targeting of energy subsidies with clear exit strategies [5].

Scientific assessment based on the available instrumental observational records from the industrial era to the present day showed that:

(a) Global mean temperature has increased by between 0.3 and 0.6 °C since the 19th century, while mean sea level has risen between 10 and 25 cm over the same period,
(b) night-time minimum temperature over land have generally increased more than the daytime temperatures and
(c) Recent years have been among the warmest since 1860, despite the cooling effect of 1991 Mount Pinatubo volcanic eruption.

The occurrences of these phenomena are due to emissions of greenhouse gases arising from human activities; especially those related to the use of fossil fuel, agricultural practices and land-use management have many side effects. Their combustion products produce pollution, acid rain and global warming. In fact the last two decades have been the warmest on record with 1998 being the warmest even with the cold La Nina conditions that dominate the year 1999. Increasing global temperature is expected to cause sea level to raise, an increase in the intensity of extreme weather events, and significant changes to the amount and pattern of precipitation. Other expected effects of global warming include changes in agricultural yields, modifications of trade routes, glacier retreat, species extinctions and increases in the ranges of disease vectors.

Climate change worries, growing support from world governments, rising oil prices and ongoing energy security concerns combined to fuel another record-setting year of investment in the renewable energy and energy efficiency industries in 2007. With end of cheap oil, renewables and energy efficiency attracts fast-growing interest; new investment surpasses $148 billion in 2007, a 60% rise from 2006, growth continues in 2008 [26b].

Renewable energy resources should therefore be key energy sources for the future. Renewable energy sources and systems can have a beneficial impact on the following essential technical, environmental, economic, and political issues of the world [6]:

- Major environmental problems (e.g. acid rain, stratospheric ozone depletion, greenhouse effect)
- Environmental degradation
- Depletion of the world's nonrenewable energy sources
- Increasing energy use in developing countries.

In order to tackle the core problems of environmental degradation, diminishing natural resources and increasing poverty an important "tool" in this process is the use of sustainable energy

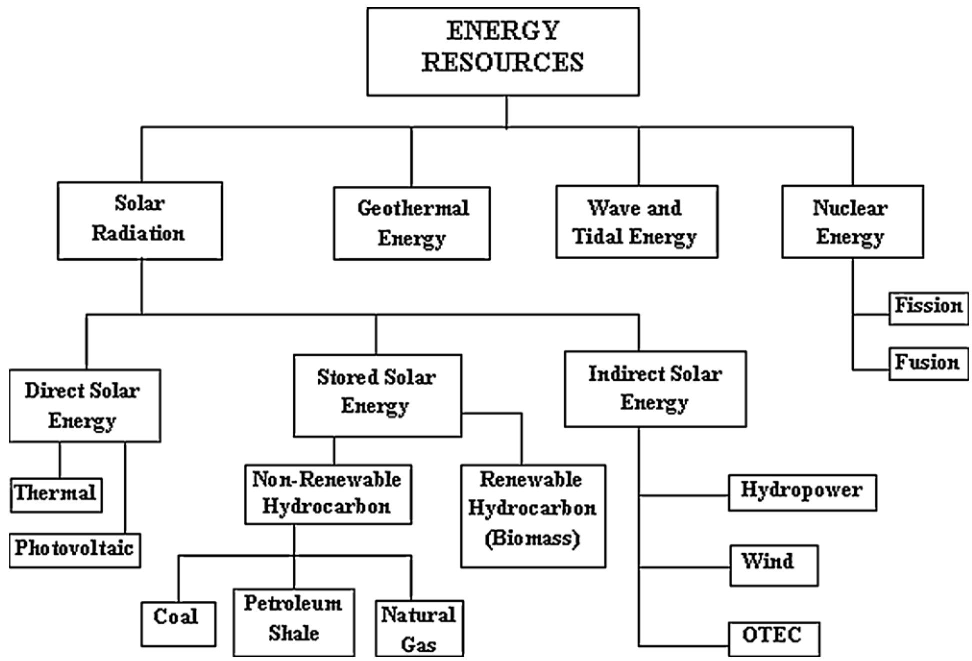

Fig. 3. Classifications of energy resources.

systems which represent an essential precondition for social and economic development of a country – together with the changing of attitudes, community mobilization and transfer of knowledge [1].

The emerging economies of Brazil, Russia, India and China (BRIC) are aggressively pursuing investments in Green Energy for power capacity growth. Brazil produced 8892 MW of renewable energy through the burning of bagasse – a waste product from sugarcane production in 2009 – to generate onsite heat and power. China announced that in order to facilitate the growth of cleaner renewable energy sources to help fuel her economic expansion, China aims to more than double its wind power capacity to 30 GW by 2020 incurring investment at least $150bn. China has also pledged to install almost 350 GW of renewable capacity by 2030 (China's National Energy Administration).

Since the cost of renewable energy is still generally higher than that for conventional fossil-fuelled generated power, all governments have to formulate stimulus packages such as generous Fit-in-Tariff for electricity generated from renewable energy, and other financial incentives.

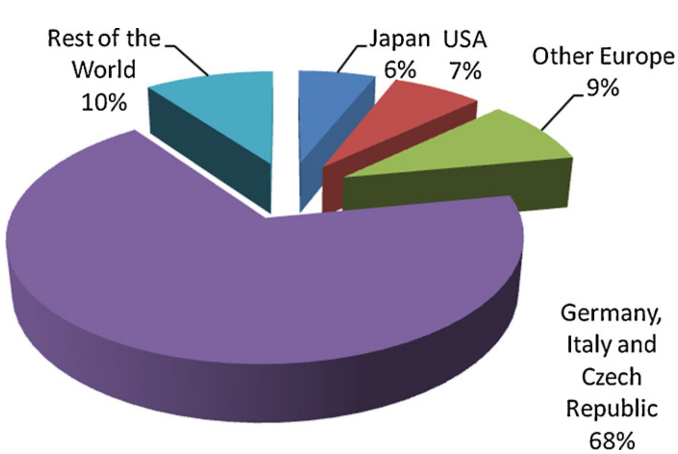

Fig. 4. Photovoltaic market of the World (2009) – 7.3 GWe.

This paper is to study the renewable energy, its implementation strategies and their obstacles for some of the selected Islamic countries. Several strategies and timeline for enhancing of widespread application of renewable energy technology are described.

2. Renewable energy resources

Fig. 3 shows the classifications of energy resources. The energy resources are divided into solar radiation, geothermal, wave and tidal, and nuclear. Solar radiation consists of direct solar, stored solar and indirect solar energy. Solar photovoltaic and solar thermal are two forms of energy classified under direct solar. Stored solar energy consists of non-renewable hydrogen carbon such as petroleum, natural gas, coal and shale and renewable hydrocarbon such as biomass and biogas. Indirect solar energy consists of hydropower and wind energy.

2.1. Solar radiation

2.1.1. Direct solar energy

2.1.1.1. Solar photovoltaic. World solar photovoltaic (PV) market installations reached a record high of 7.3 GWe in 2009 as shown in Fig. 4, representing growth of 20% over the previous year. The PV industry generated USD38.5 billion in global revenues in 2009, while successfully raising over USD13.5 billion in equity and debt, up 8% on the prior year [26c].

Fig. 5 shows the photovoltaic production of the panels by countries. China is the largest producer followed by Germany and Japan. Among the OIC member country, Malaysia produced about 3% of the world photovoltaic panels in 2009 largely attributed to Foreign Direct Investment (FDI) by First Solar (USA) and Q Cells (Germany). Malaysia is projected to contributed about 11% of the world production with the production of solar cells from Sun Power (USA) in Malaysia as shown in Fig. 6 [7]. The only local solar panel manufacturer in Malaysia is Solartiff Sdn Bhd which has the capabilty of producing 1 MWe per year. Fig. 7 shows the application of solar photovoltaic system in the world in 2008 that estimates by Navigant Consulting, Envision, Goldman Sachs [26d].

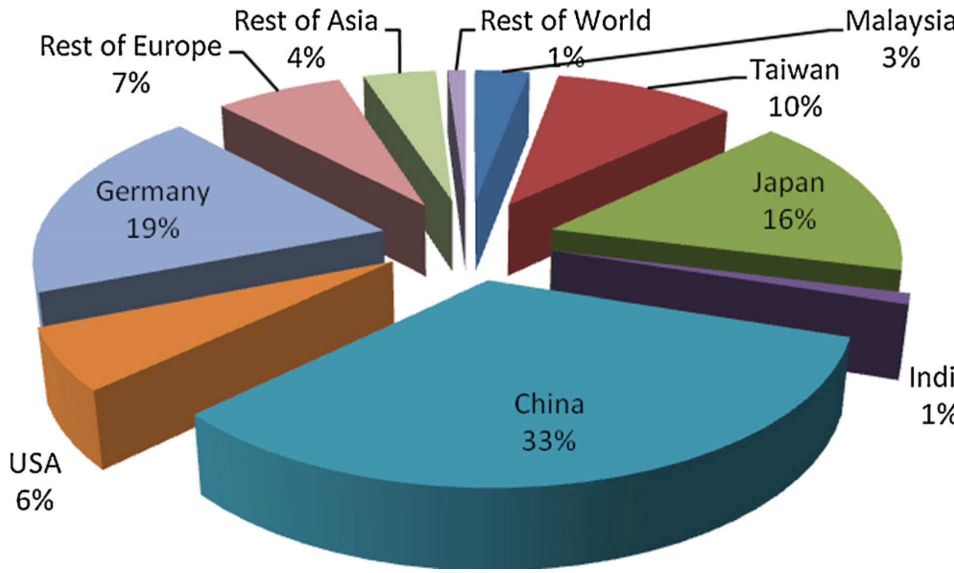

Fig. 5. PV production in 2009 (7.3 GWe).

2.1.1.2. Solar thermal technology. The most important component of solar thermal technology is the solar thermal collector. A solar thermal collector is designed to collect heat by absorbing sunlight. Solar thermal collectors fall into two general categories: non-concentrating and concentrating. In the non-concentrating type, the collector area (i.e. the area that intercepts the solar radiation) is the same as the absorber area (i.e., the area absorbing the radiation). In these types the whole solar panel absorbs the light.

For flat plat collectors, OIC countries that have manufacturing facilities are Malaysia, Turkey, Iran, and Indonesia. As for concentrating solar collectors several OIC countries such as Iran and Kuwait has large scale application for power generation.

Solar hot water heater: Flat plate and evacuated tube solar collectors are used to collect heat for space heating or domestic hot water. They consist of (a) a dark flat-plate absorber of solar energy, (b) a transparent cover that allows solar energy to pass through but reduces heat losses, (c) a heat-transport fluid (air, antifreeze or water) flowing through tubes to remove heat from the absorber, and (d) a heat insulating backing. The absorber consists of a thin absorber sheet (of thermally stable polymers, aluminum, steel or copper, to which a black or selective coating is applied) backed by a grid or coil of fluid tubing placed in an insulated casing with a glass or polycarbonate cover. Fluid is circulated through the tubing to transfer heat from the absorber to an insulated water tank. This may be achieved directly or though a heat exchanger. Some fabricates have a completely flooded absorber consisting of two sheets of metal stamped to produce a circulation zone. Because the heat exchange area is greater they may be marginally more efficient than traditional absorbers.

As an alternative to metal collectors, new polymer flat plate collectors. These may be wholly polymer, or they may include metal plates in front of freeze-tolerant water channels made of silicone rubber. Polymers, being flexible and therefore freeze-tolerant, are able to contain plain water instead of antifreeze, so that they may be plumbed directly into existing water tanks instead of needing to use heat exchangers which lowers efficiency. By dispensing with a heat exchanger in these flat plate panel, temperatures need not be quite so high for the circulation system to be switched on, so such direct circulation panels, whether polymer or otherwise, can be more efficient, particularly at low light levels. However, polymer collectors suffer from overheating when insulated, as stagnation temperatures can exceed the melting point of the polymer. For example, the melting point of polypropylene is 160 °C, while the stagnation

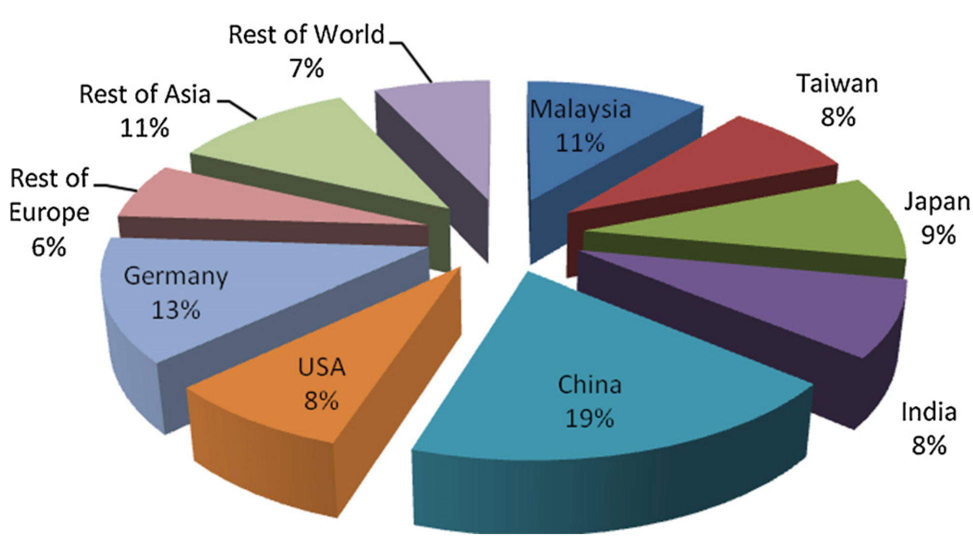

Fig. 6. Projected PV production in 2011 (18 GWe).

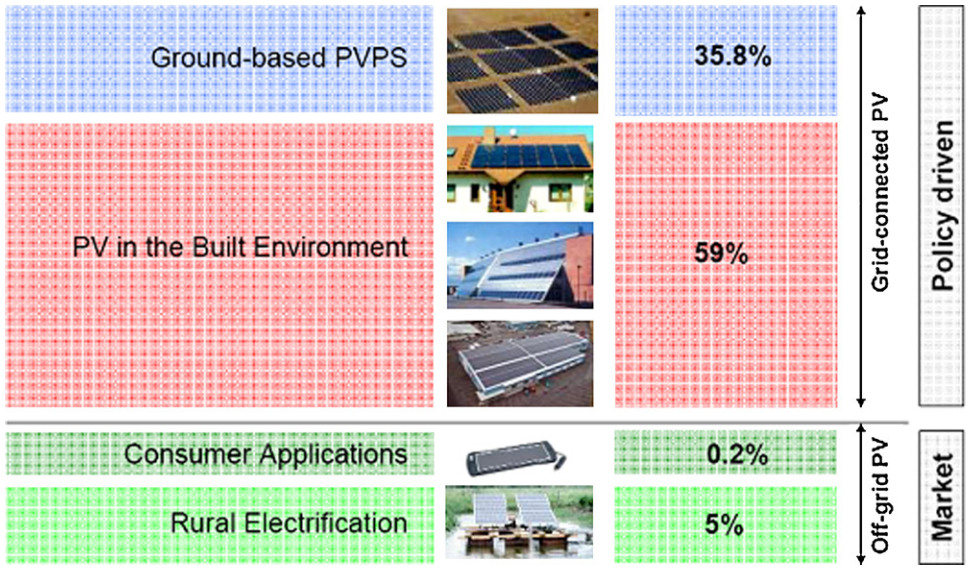

Fig. 7. PV application split in 2008.

temperature of insulated thermal collectors can exceed 180 °C if control strategies are not used.

Evacuated tubes: Evacuated tube collectors have multiple evacuated borosilicate glass tubes which heat up solar absorbers and, ultimately, solar working fluid (water or an antifreeze mix – typically propylene glycol) in order to heat domestic hot water, or for hydronic space heating. The vacuum within the evacuated tubes reduces convection and conduction heat losses, allowing them to reach considerably higher temperatures than most flat-plate collectors. Two types of tube collectors are distinguished by their heat transfer method: the older type pumps a heat transfer fluid (water or antifreeze) through a U-shaped copper tube in each of the glass collector tubes. A newer type uses a sealed heat pipe that contains a liquid that vapourises as it is heated. The vapour rises to a heat-transfer bulb positioned outside the collector tube in a manifold through which water (in direct systems) or heat transfer fluid (HTF in indirect systems) is pumped. The vacuum that surrounds the outside of the tube reduces heat loss to the outside, therefore the greater efficiency of evacuated tube collectors. Therefore they can perform well in colder conditions. The advantage is largely lost in warmer climates, except in those cases where very hot water is desirable, for example commercial process water. The high temperatures that can occur may require special system design to avoid or mitigate overheating conditions though some have built in temperature limitation.

Solar air heater: The basic components of a solar air heater system include solar collector panels, a duct system and diffusers. Systems can operate with or without a fan. Without a fan the air is distributed by the action of a natural ventilation system. Air is heated in a collector and either transferred directly to the interior space or to a storage medium, such as a rock bin. Solar air heaters use solar panels to warm air which is then conveyed into a room or drying chamber for drying of marine or agricultural produce.

Photovoltaic thermal collectors: The term photovoltaic thermal collector or PVT refers to solar thermal collectors that use PV cells as an integral part of the absorber plate. The system generates both thermal and electrical energy simultaneously. The number of the photovoltaic cells in the system can be adjusted according to the local load demands. In conventional solar thermal system, external electrical energy is required to circulate the working fluid through the system. The need for an external electrical source can be eliminated by using this hybrid system. With a suitable design, one can produce a self-sufficient solar collector system that requires no external electrical energy to run the system. The different options in the development in PVT systems have been categorized by the heat transfer fluid used i.e. air, water, refrigerant. The choice of the heat transfer fluid is fundamental to the design of PVT systems.

2.1.2. *Indirect solar energy*

2.1.2.1. Wind energy. In spite of the global economic crisis, investment in new wind turbines exceeded by far all previous years. The wind capacity worldwide in 2009 reached 159,213 MWe, after 120,903 MWe in 2008, 93,930 MWe in 2007, 74,123 MWe in 2006, and 59,012 MWe in 2005. Hence, the installed wind capacity is more than doubling every third year. The market for new wind turbines showed a 42.1% increase and reached an overall size of 38,312 MWe, after 26,969 MWe in 2008, 19,808 MWe in 2007 and 15,111 MWe in the year 2006. Ten years ago, the market for new wind turbines had only a size of 4 GWe, only one tenth of the size of 2009. Table 1 shows the world wind energy growth rate and installed power [26e].

The growth rate is the relation between the new installed wind power capacity and the installed capacity of the previous year. The annual growth rate continued to increase since the year 2004, reaching 31.7% in 2009 – the highest rate since 2001 – after 29.0% in 2008, 26.6% in 2007, 25.6% in the year 2006 and 23.8% in 2005. The highest growth rates of the year 2009 with more than 100% could be found in Mexico which quadrupled its installed capacity, once again in Turkey (132%) which had the highest rate in the previous year, in China (113%) as well as in Morocco (104%). It is encouraging to see that two of these four of the most dynamic markets can be found in the African OIC countries, which is still lagging behind the rest of the world in the commercial use of wind power.

All wind turbines installed in Africa in 2009 had a capacity of 770 MWe (0.5% of the total worldwide capacity), out of which 169 MWe were added in two countries, Egypt and Morocco. New wind projects are on the way in the leading countries Egypt and Morocco, but also in new markets like in the already mentioned Tunisia as well as in It is encouraging to see that industrial activities in manufacturing of wind turbines have started in the African OIC countries as well, mainly in Egypt.

It can be expected that the creation of stable markets on the continent has the potential to lead to the establishment of domestic wind industries in several African OIC countries. In light of the fact that the majority of the African population still has no access to electricity grids, small, decentralised and stand-alone wind energy

Table 1
World wind energy growth rate and installed power.

Position 2009	Country/region	Total capacity end 2009 [MW]	Added capacity 2009 [MW]	Growth rate 2009 [%]	Position 2008	Total capacity end 2008 [MW]	Total capacity end 2007 [MW]	Total capacity end 2006 [MW]
1	USA	35,159.0	9922.0	39.3	1	25,237.0	16,823.0	11,575.0
2	China	26,010.0	13,800.0	113.0	4	12,210.0	5912.0	2599.0
3	Germany	25,777.0	1880.0	7.9	2	23,897.0	22,247.4	20,622.0
4	Spain	19,149.0	2460.0	14.7	3	16,689.0	15,145.1	11,630.0
5	India	10,925.0	1338.0	14.0	5	9587.0	7850.0	6270.0
6	Italy	4850.0	1114.0	29.8	6	3736.0	2726.1	2123.4
7	France	4521.0	1117.0	32.8	7	3404.0	2455.0	1567.0
8	United Kingdom	4092.0	897.0	28.1	8	3195.0	2389.0	1962.9
9	Portugal	3535.0	673.0	23.5	10	2862.0	2130.0	1716.0
10	Denmark	3497.0	334.0	10.6	9	3163.0	3125.0	3136.0
11	Canada	3319.0	950.0	40.1	11	2369.0	1846.0	1460.0
12	The Netherlands	2240.0	5.0	0.2	12	2235.0	1747.0	1559.0
13	Japan	2056.0	176.0	9.4	13	1880.0	1528.0	1309.0
14	Australia	1877.0	383.0	25.6	14	1494.0	817.3	817.3
15	Sweden	1579.0	512.0	48.0	16	1066.9	831.0	571.2
16	Ireland	1260.0	233.0	22.7	15	1027.0	805.0	746.0
17	Greece	1109.0	119.0	12.0	18	989.7	873.3	757.6
18	Austria	995.0	0.0	0.0	17	994.9	981.5	964.5
19	**Turkey**	**796.5**	**463.1**	**138.9**	**25**	**333.4**	**206.8**	**64.6**
20	Poland	666.0	194.0	41.1	19	472.0	276.0	153.0
21	Brazil	600.0	261.5	77.3	24	338.5	247.1	236.9
22	Belgium	555.0	171.0	44.6	22	383.6	286.9	194.3
23	New Zealand	497.0	172.0	52.9	26	325.3	321.8	171.0
24	Chinese Taipeh	436.0	78.0	21.8	23	358.2	279.9	187.7
25	Norway	431.0	2.0	0.5	20	429.0	333.0	325.0
26	**Egypt**	**430.0**	**40.0**	**10.3**	**21**	**390.0**	**310.0**	**230.0**
27	Mexico	402.0	317.0	372.9	34	85.0	85.0	84.0
28	Korea(South)	364.4	86.4	31.1	27	278.0	192.1	176.3
29	**Morocco**	**253.0**	**129.0**	**104.0**	**32**	**124.0**	**125.2**	**64.0**
30	Bulgaria	214.2	56.7	36.0	28	157.5	56.9	36.0
31	Hungary	201.0	74.0	58.3	31	127.0	65.0	60.9
32	Czech Republic	191.0	41.0	27.3	29	150.0	116.0	56.5
33	Finland	147.0	4.0	2.8	30	143.0	110.0	86.0
34	Estonia	142.3	64.0	81.8	36	78.3	58.6	33.0
35	Costa Rica	123.0	49.5	66.9	37	74.0	74.0	74.0
36	Lithuania	91.0	37.0	68.0	38	54.4	52.3	55.0
37	Ukraine	90.0	0.0	0.0	33	90.0	89.0	85.6
38	**Iran**	**82.0**	**0.0**	**0.0**	**35**	**82.0**	**66.5**	**47.4**
39	Chile	78.0	58.0	288.6	47	20.1	20.1	2.0
40	Nicaragua	40.0	40.0	new	new	0.0	0.0	0.0
41	Luxembourg	35.3	0.0	0.0	39	35.3	35.3	35.3
42	Philippines	33.0	8.0	31.8	42	25.2	25.2	25.2
43	Argentina	29.8	0.0	0.0	41	29.8	29.8	27.8
44	Jamaica	29.7	9.0	43.5	44	20.7	20.7	20.7
45	Latvia	28.5	1.6	5.9	40	26.9	26.9	26.9
46	Croatia	27.8	9.6	52.9	50	18.2	17.2	17.2
47	Netherlands Antilles	24.3	12.0	97.6	54	12.3	12.3	12.0
48	South Africa	21.8	0.0	0.0	43	21.8	16.6	16.6
49	Guadeloupe	20.5	0.0	0.0	45	20.5	20.5	20.5
49	Uruguay	20.5	0.0	0.0	46	20.5	0.6	0.2
51	Colombia	20.0	0.0	0.0	49	19.5	19.5	19.5
51	**Tunisia**	**20.0**	**0.0**	**0.0**	**48**	**20.0**	**20.0**	**20.0**
53	Switzerland	17.6	4.0	29.0	52	13.8	11.6	11.6
54	Russia	16.5	0.0	0.0	51	16.5	16.5	15.5
55	Romania	14.0	7.0	100.0	56	7.0	7.8	2.8
56	**Guyana**	**13.5**	**0.0**	**0.0**	**53**	**13.5**	**13.5**	**13.5**
57	Vietnam	8.8	7.5	600.0	66	1.3	0.0	0.0
58	Cuba	7.2	0.0	0.0	55	7.2	2.1	0.5
59	Israel	6.0	0.0	0.0	57	6.0	6.0	7.0
59	Slovakia	6.0	0.0	0.0	58	6.0	5.0	5.0
59	**Pakistan**	**6.0**	**0.0**	**0.0**	**58**	**6.0**	**0.0**	**0.0**
62	Faroe Islands	4.1	0.0	0.0	60	4.1	4.1	4.1
63	Cape Verde	2.8	0.0	0.0	62	2.8	2.8	2.8
64	Ecuador	2.5	0.0	0.0	61	4.0	3.1	0.0
65	Mongolia	2.4	0.0	0.0	63	2.4	0.0	0.0
66	**Nigeria**	**2.2**	**0.0**	**0.0**	**64**	**2.2**	**2.2**	**2.2**
67	Belarus	1.9	0.9	77.3	68	1.1	1.1	1.1
68	Antarctica	1.6	1.0	165.0	73	0.6	0.0	0.0
69	**Jordan**	**1.5**	**0.0**	**0.0**	**65**	**1.5**	**1.5**	**1.5**
70	**Indonesia**	**1.4**	**0.2**	**16.7**	**67**	**1.2**	**1.0**	**0.8**
71	Martinique	1.1	0.0	0.0	68	1.1	1.1	1.1
72	Falkland Islands	1.0	0.0	0.0	70	1.0	1.0	1.0
73	Eritrea	0.8	0.0	0.0	71	0.8	0.8	0.8

Table 1 (*Continued*)

Position 2009	Country/region	Total capacity end 2009 [MW]	Added capacity 2009 [MW]	Growth rate 2009 [%]	Position 2008	Total capacity end 2008 [MW]	Total capacity end 2007 [MW]	Total capacity end 2006 [MW]
74	Peru	0.7	0.0	0.0	72	0.7	0.7	0.7
75	**Kazakhstan**	**0.5**	**0.0**	**0.0**	**74**	**0.5**	**0.5**	**0.5**
75	Namibia	0.5	0.0	0.0	74	0.5	0.5	0.3
75	**Syria**	**0.5**	**0.1**	**22.5**	**76**	**0.4**	**0.3**	**0.3**
78	Dominican Republic	0.2	0.0	0.0	77	0.2	0.0	0.0
79	Dominica	0.2	0.0	0.0	77	0.2	0.0	0.0
80	North Korea	0.2	0.0	0.0	77	0.2	0.0	0.0
81	**Algeria**	**0.1**	**0.0**	**0.0**	**80**	**0.1**	**0.0**	**0.0**
82	Bolivia	0.01	0.0	0.0	81	0.01	0.01	0.01

Bold entries: OIC member countries.

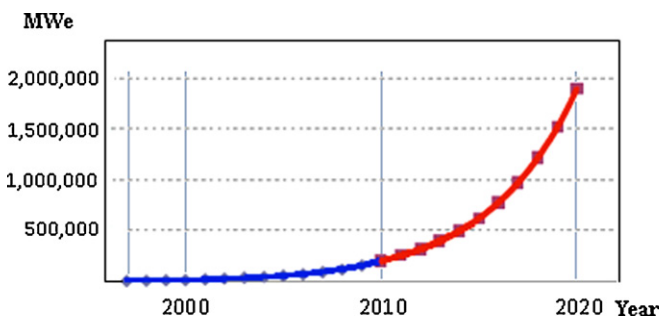

Fig. 8. Total worldwide installed wind capacity 1997–2020 (MWe): Development & Prognosis.

systems, in combination with other renewable energies, will have to play a key role. This process of deploying technologies for rural electrification is still in its early stage. The main limiting factors are still the lack of access to know-how as well as to financial resources. In this context, the outcome of the UN climate change discussions and the potential establishment of a Global Fund for Renewable Energy Investment would offer huge opportunities for many African OIC countries to bypass one of the major barriers for wind energy investments: the lack of financing options.

Future prospects of wind capacity worldwide will exceed 1,900,000 MWe in 2020, as shown in Fig. 8, and only 11,900 MWe in OIC countries at an average growth rate of 20% per year [26e]. It is evident that the percentage of total wind capacity in OIC countries to the total worldwide wind capacity (TWWC) only improves from 1.0% in 2010 to 2.0% in 2020.

The wind sector showed impressive growth rates in the year 2009 perhaps due to an increase in awareness of the importance of wind energy and its economic, social and environmental benefits.

Investments in wind energy farms in OIC countries will continue to grow at an average growth rate of 25% per year in tandem with global wind markets due to much anticipated improvement in world financial markets, improvement in wind power generation technologies, additional financial and tax incentives, worldwide adoption of Feed-in-Tariff (FiT) by respective countries and improved community power ownership models as developed and applied in Scotland and Canada, Australia, South Africa and in many other parts of the world. Therefore it can be predicted that the installed wind generation capacity in OIC countries will be 11,900 MWe by 2020 (WWEA projected the installed global wind generation capacity to be at least 1,900,000 MWe by 2020), as shown in Fig. 9.

2.1.2.2. Hydropower. Hydroelectricity is the term referring to electricity generated by hydropower; the production of electrical power through the use of the gravitational force of falling or flowing water. It is the most widely used form of renewable energy. Once a hydroelectric complex is constructed, the project produces no direct waste, and has a considerably lower output level of the greenhouse gas carbon dioxide (CO_2) than fossil fuel powered energy plants. Worldwide, an installed capacity of 777 GWe supplied 2998 TWh of hydroelectricity in 2006. This was approximately 20% of the world's electricity, and accounted for about 88% of electricity from renewable sources.

Although no official definition exist for the capacity range of large hydroelectric power stations, facilities from over a few hundred megawatts to more than 10 GW is generally considered large hydroelectric facilities. Currently, only three facilities over 10 GW (10,000 MW) are in operation worldwide; Three Gorges Dam at 22.5 GW, Itaipu Dam at 14 GW, and Guri Dam at 10.2 GW. Large-scale hydroelectric power stations are more commonly seen as the largest power producing facilities in the world, with some hydroelectric facilities capable of generating more than double the installed capacities of the current largest nuclear power stations.

Small hydro is the development of hydroelectric power on a scale serving a small community or industrial plant. The definition of a small hydro project varies but a generating capacity of up to 10 megawatts (MW) is generally accepted as the upper limit of what can be termed small hydro. This may be stretched to 25 MW and 30 MW in Canada and the United States. Small-scale hydroelectricity production grew by 28% during 2008 from 2005, raising the total world small-hydro capacity to 85 GW. Over 70% of this was in China (65 GW), followed by Japan (3.5 GW), the United States (3 GW), and India (2 GW). Small hydro plants may be connected to conventional electrical distribution networks as a source of low-cost renewable energy. Alternatively, small hydro projects may be built in isolated areas that would be uneconomic to serve from a network, or in areas where there is no national electrical distribution network. Since small hydro projects usually have minimal reservoirs and civil construction work, they are seen as having a relatively low environmental impact compared to large hydro. This decreased environmental impact depends strongly on the balance between stream flow and power production.

Micro hydro is a term used for hydroelectric power installations that typically produce up to 100 kW of power. These installations can provide power to an isolated home or small community, or are sometimes connected to electric power networks. There are many of these installations around the world, particularly in developing nations as they can provide an economical source of energy without purchase of fuel. Micro hydro systems complement photovoltaic solar energy systems because in many areas, water flow, and thus available hydro power, is highest in the winter when solar energy is at a minimum.

Pico hydro is a term used for hydroelectric power generation of under 5 kW. It is useful in small, remote communities that require only a small amount of electricity. For example, to power one or two fluorescent light bulbs and a TV or radio for a few homes. Even smaller turbines of 200–300 W may power a single home in a developing country with a drop of only 1 m (3 ft). Pico-hydro setups typically are run-of-the-river, meaning that dams are not used, but

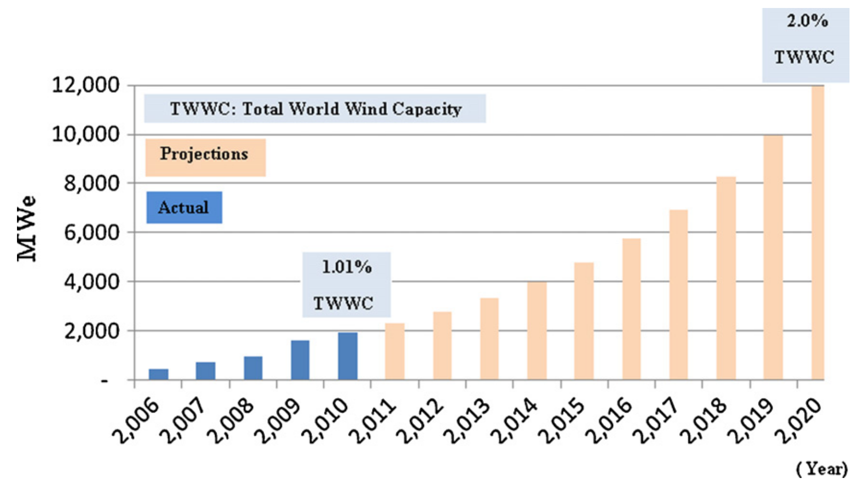

Fig. 9. Projections of total wind capacity (MWe) in OIC countries from 2010 to 2020.

rather pipes divert some of the flow, drop this down a gradient, and through the turbine before being exhausted back to the stream.

2.1.2.3. Ocean thermal energy conversion. Ocean thermal energy conversion is commonly known as OTEC. OTEC systems use the ocean's natural thermal gradient. The thermal gradient is due to the fact that the ocean's layers of water have different temperatures that can drive a power producing cycle. The system can produce significant amount of power as long as the temperature between the warm surface water and the cold deep water differs by 20 °C.

No activities are reported for the OIC countries. A number of islands in the Caribbean, Pacific, and the Mediterranean have the conditions suitable for OTEC. The potential of OTEC is estimated to be 10 TW (10^{13} W) of base load power generation. The cold, deep seawater used in the OTEC process is also rich in nutrients, and it can be used to culture both marine organism and plant life near the shore or on land. OTEC is very promising and useful as alternative energy resource for tropical island communities that rely heavily on imported fuel. The OTEC plant in this community can also provide power, desalinated water and variety of marine culture products. The most significant achievement in OTEC technology was the production of a record 50 kW of electricity during a net power producing experiment with an open-cycle OTEC plant in Keahole Point, Hawaii.

There is a general realization among those working on OTEC technology that the time is right to go ahead with small scale, which would provide sufficient operation information to plan, design and fund commercial OTEC plants. The size of this early commercial pilot plant would vary between 2 and 10 MWe.

2.2. Geothermal

In 2005, there were 8933 MW of installed power capacity in 24 countries, generating 55,709 GWh per year of green power, according to the International Geothermal Association. IGA reports in 2010 that 10,715 MW is on line generating 67,246 GWh. This represents a 20% increase in geothermal power on line between 2005 and 2010. IGA projects this will grow to 18,500 MW by 2015, which based upon the large number of projects under consideration appears reasonable if not conservative [8].

The countries with the greatest increase in installed capacity (MW) between 2005 and 2010 were: (1) US – 530 MW, (2) Indonesia – 400 MW, (3) Iceland – 373 MW, (4) New Zealand – 193 MW, and (5) Turkey 0.62 MW. In terms of the percentage increase the top five countries were (1) German – 2774%, (2) Papua-New Guinea – 833%, (3) Australia – 633%, (4) Turkey – 308%, and (5) Iceland – 184%.

Turkey has reached 550 MW in 2010 and has a goal to reach 550 MW of geothermal power on line by 2013.Nearly 274 geothermal fields are documented, with a proven potential of 3293 MW. Total geothermal potential estimates are 31,500 to 35,600 MW. Installed capacity for direct usage is 1177 MW [9].

Indonesia's National Energy Blueprint sets a goal of 9500 MW of geothermal power production, an 800% increase. With an impressive 33,000 MW potential, Indonesia has approximately 40% of the world geothermal energy reserves. Of that, 1197 MW has been exploited. Indonesia ranks third in the world in terms of geothermal energy consumption, after the US and the Philippines. It is also the third biggest emitter of greenhouse gases and aims to cut emissions by 16% by 2025. The Indonesian government recently announced it has signed US$ 5 billion worth of geothermal energy deals, and it has a goal to reach 9000 MW from geothermal resources by 2025 and to be the world's largest producer of geothermal energy [9].

Geothermal resources in Algeria are primarily utilized for balneotherapy and thermal resorts, although there has been a recent spike in interest of geothermal aquaculture projects, three sites having already been selected for this purpose. Some direct use application also exists in the country, with at least one school deriving its heating and cooling via a geothermal heat pump. Djibouti is reportedly working with Reykjavik Energy to plan for a 50 MW geothermal power plant in the Asal area to be completed by 2012. According to additional studies conducted in the Asal region, three independent subfields exist in the area. If the plant is later expanded as anticipated, it could generate 100–150 MW electricity from geothermal resources. Tunisia's geothermal resources are largely employed for irrigation and direct-use heating of the country's greenhouses [9]. Pursuant to a 2009–2014 Presidential program, Tunisia plans to double the 194,000 ha currently used for geothermal farming to 310,000 ha in 2010 Tunisia is ranked third in the world for agricultural application of geothermal resources (the first two positions being occupied by the US and Hungary, respectively). Tunisia's geothermal development has benefited from foreign investments, which are facilitating the country's regional development strategy goal of reaching 150 ha of greenhouses by 2016. Foreign capital is also contributing to executing Tunisia's 2005 framework policy on energy conservation and renewable energy which, among other objectives, aims to enhance energy capitalization of geothermal waters. Up to 47% of the Yemen Geothermal Development Project is being financed by the Global Environment Facility (GEF) Trust Fund, which aims to "accelerate

the exploration and the development of geothermal power use in Yemen." [9].

Geothermal exploration in Iran has gain momentum in the last five years, with increased exploration and foreign technology sharing spurring industry growth in the country. In addition to numerous feasibility studies related to geothermal heat pumps, Iran is also developing a geothermal plant for power production and exploring the possibility of using wastewater frothe plant for direct use. In January 2010, Iran's deputy minister for electricity Abbas Aliabadi said the Iranian government plans to build 2000 MW of renewable energy capacity over the next five years.

2.3. Wave and tidal energy

Wave energy generates electricity, heat or mechanical energy from ocean wave. Some other applications beside electricity generation include desalination, pumping of seawater for marine cultures are potentially viable. No activities are conducted in the OIC countries. A number of pilot schemes have been installed in Asia, Europe and the United States. The total exploitable word wave power resource is estimated to be 2–5 TW (10^{12} W), largely to be found in offshore locations where the water is deeper than 40 m, and the power density can be 50–70 kW/m of wave crest. The shoreline resource, although easier to exploit, has a lower power density (around 20 kW/m) since the energy content of waves is partially dissipated as they run through shallow water on their approach the shore. Several prototype wave energy converters were commissioned around the world and the significant in size being the demonstration projects in Norway, a 600 kW oscillating water column and a 350 kW Tapchan (tapered channel), which are out of operation. However, they successfully demonstrated the principles and subsequent developments have benefited from the experience gained.

Tidal energy uses the force of incoming–outgoing flow of water in the same technique that hydroelectric plants use the flow of falling water. Each tidal site is specific and the engineering must reflect a design that will ensure adequate water flow. Although there are only few tidal plants in operation, several exploratory facilities have been constructed. At La Rance, France, a 240 MW facility is currently in operation. Canada has built a plant on the large tidal flats located in the Bay of Fundy. In 1989, the Chinese government erected several small tidal plants, and completed a 10 MW plant in the Zhejang Province. These types of technologies will not be of any importance in supplying energy in the immediate future, but also, research and development deserve support as a future potential source of vast amounts of energy.

2.3.1. Stored solar energy

2.3.1.1. Bioenergy. Bioenergy (biomass, biogas, liquid biofuels) is renewable energy derived from biological sources such as forestry and agriculture crops, biomass residues and wastes which already provide about 14% of the world's primary energy supplies, with the potential to meet up to half of world energy demands during the next century. Bioenergy has its own pitfalls and require further research and development on, production, management and oversite for it to be more commercially competitive.

Biomass: OIC member countries producing palm oil such as Malaysia and Indonesia can generate power using empty fruit bunch. The greatest source of biomass in Malaysia is from oil palm empty fruit bunch (EFB) which can generate approximately 5% of the country's total energy requirements in an environmentally friendly and sustainable manner. Malaysia's Renewable Energy Power Purchase Agreement (REPPA) allows IPPs to sell their excess power from the power plants to Tenaga National Berhad (electrical power utility company) at a tariff rate of 21 sen/kWh (6.36 UScents/kWh, RM3.3 = USD1.0), for IPPs exporting to TNB less than 10 MWe. This tariff is expected to be increased to 42 sen/kWh (12.7 UScents/kWh, RM3.3 = USD1.0) in 2011. An additional benefit in the cash flow of these plants is the prospect of selling the residual ash as fertilisers for about USD300,000 per year.

Normally the construction of 10 MWe biomass plant, which consumes EFB approximately 650 ton/h, takes about 24 months at the capital cost of USD25 million. The investment payback period is about 7 years. The Kyoto's Protocol on Clean Development Mechanism (CDM) qualifies renewable energy projects in developing countries to benefit from the carbon credits against a developed country's emission obligation. Typically a 10 MW EFB-fired IPP enjoys some USD1.0 million/year from the CDM carbon credits.

Liquid biofuels: Microalgae are so diverse, pervasive, productive and less competitive with other plants as a source of food for human consumption. The economic viability of aqua-culturing microalgae for the production of biodiesel in quantities large enough to replace fossil fuels faces several challenges. These include lack of sufficient suitable land having near optimal climatic conditions, as well as necessary nutrient media sources nearby and, supporting industry, infrastructure and transport facilities. Sub-optimal level of control of variables in open systems, diurnal, seasonal and climatic variation, biological contamination of algal media, sub-optimal algal strain selection, mix and modification, lack of any high-level life cycle analysis of GHG emissions, difficulties in scaling-up from small-scale photo bioreactors to commercially viable production facilities.

Further research and a high degree of product innovation, most dedicated algae-to biodiesel conversion projects also face uneconomically high costs for site acquisition and preparation, bioreactor construction materials, construction, deployment and reconstruction, chemical and energy inputs, algae harvesting, dewatering and concentration, lipid extraction, biodiesel and by-product processing, surveillance, process control and maintenance, and transport.

Diesel-like fuel can also be obtained from microalgae. Certain species of microalgae offer the possibility of a sustainable, low GHG emissions feedstock for the production of liquid biofuels that, grows rapidly, yields significantly more liquid biofuel per hectare than oil plants, can sequester excess carbon dioxide as hydrocarbons, contains no sulphur and has low toxicity, is highly biodegradable, does not compete significantly with food, fibre or other uses, does not involve destruction of natural habitats.

Microalgae contain lipids and fatty acids as membrane components, storage products, metabolites and sources of energy. When grown under standard, nutrient-replete conditions, microalgae show large differences in percentages of the key macronutrients: by dry weight, typically 25–40% of protein, 5–30% of carbohydrate and 10–30% of lipids/oils. Species containing considerably higher oil content have been found as possible candidates for producing biodiesel.

Microalgae, which produced most fossil fuels originally, need light, nutrients and warmth to grow. On a large-scale, this occurs naturally in bogs, marshes and swamps, salt marshes or salt lakes. Smaller-scale sources include wastewater treatment ponds, animal waste and other liquid wastes. When algae growth conditions exist, the steps involved in producing biodiesel from the algae are shown in Fig. 10 [10].

Indonesia planned to develop 2.4 million kiloliters of liquid biofuel from sources like jatropha and palm oil starting from 2010, replacing 10% of diesel fuel consumption and is projected to increase to 20% by 2025. The target for bioethanol production is 15% of gasoline consumption by 2025. Bio-ethanol will be blended with gasoline gradually from E-5 to E-15 by 2015 for non-flexible fuel vehicles (FFVs) while up to 40% for FFVs.

Indonesia also planned to develop bioethanol feed stocks mainly from sugarcane and cassava. However, other sources such as

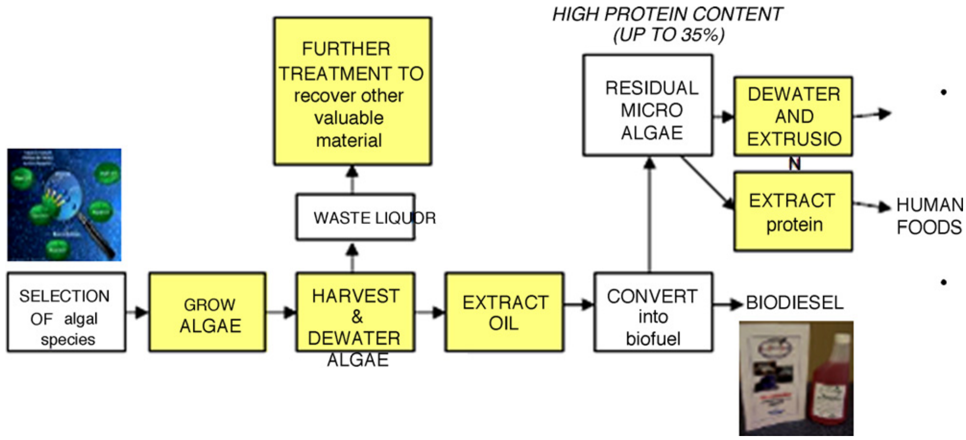

Fig. 10. Pathway of algae to biodiesel.

Table 2
Potential sources of bio-ethanol feedstock.

Sources	Yield per ha/year	Ethanol (l/ha/year)
Arrenga Pinnata	0.6–1.2 million l	40,000
Sugarcane	40–120 ton	3000–8500
Cassava	10–50 ton	2000–7000
Sweet sorghum	20–60 ton	2000–6000
Sorghum	3–12 ton	1500–5000
Sweet potato	10–40 ton	1200–5000
Corn	1–6 ton	400–2500
Molasses	2000 l	500

arrenga pinnata, and sweet sorghum and those shown in Table 2 can be used as a potential feedstock [11].

Indonesia can produce a total of 940 million l/year by 2010 from 11 big scale bio-ethanol manufacturers each with production capacity ranging from 3.6 to 50 millions l/year. Production of bioethanol at 95% will be used mainly for industrial supplies. So far only one plant has the capacity to produce fuel grade bio-ethanol at 99.5%. The conversion of 7 millions l/year 95% bio-ethanol to fuel grade molecular sieve costs Rp 5–7.5 trillions (USD750 million). Small scale distillers of DME with investment cost varying from Rp 2 millions to Rp 100 millions (USD10,000) are also expected to grow. For economic reasons, in order to maintain quality of fuel grade ethanol to Indonesia's Standard SNI Bioethanol No. DT-27-0001-20 6, small scale plants should produce ethanol between 90 and 96%, while dehydration to 99.5% should be done only by medium and big scale distilleries [12].

Although liquid biofuels have been used since the invention of diesel engine, the current technologies have resulted in highly efficient electrical power generation system using medium-speed diesel engines which convert liquid biofuels (conventionally heavy fuel oil (HFO)) directly into electric energy even under the most extreme conditions.

Liquid biofuel power plants rely on dependable, renewable resources and offer high overall plant performance at all times. Many engine manufacturers have developed technical solutions to meet both needs: liquid biofuel power plants offer sustainable stable power generation not depending on weather conditions with practically zero greenhouse gas emissions.

At its best, biofuel production creates local job opportunities, thus promoting social and economic cohesion. It also improves regional fuel supply security by reducing the need for imported fuels. In some cases, energy crop cultivation might even help to fight soil erosion.

There are now combined cycle biofuel plants below 50 MWe, such as shown schematically in Fig. 11 [13]. Typically the plant comprises an exhaust gas silencer, Selective Catalytic Reduction (SCR) unit for abatement of NOx emissions, engine-generator set, exhaust gas boiler to recover the exhaust heat and a steam turbine. The electrical efficiency is high (49.2% gross) when exhaust heat is recovered to generate additional power using the Organic Rankine Cyle (ORC) and an ordinary condensing steam turbine. These plants emit much reduced total greenhouse emissions because they do not require any supplementary energy for fuel refinement, hence even the CO_2 emissions associated with the fuel refinement are minimized. The sulphur emissions are insignificant compared to those associated with fossil fuels because vegetable oils do not contain significant amounts of sulphur. NOx is reduced tremendously to about 85%. Particle emissions (PM), which depends on ash content of the biofuels, in power plants burning good-quality liquid biofuel now meet the stringent European standards. CO and UHC emissions are low due to the highly efficient diesel engine process. The power is also generated with minimal use of water, so the impact on water resources is negligible.

3. Hydrogen energy and fuel cell

Scientists have dreamed of the ultimate source of energy that will power the world forever. This ultimate source is hydrogen. Hydrogen can be produced by the electrolysis of water and when burned in oxygen produces only energy and water, without any of the green house gases. However, when hydrogen is burnt in air oxides of nitrogen, the old green house gases will be produced also. A cleaner way to get energy from hydrogen is through the fuel cell. The fuel cell is an electrochemical cell, which produces electricity directly from hydrogen and air, without the production of green house gases. Research and development on the fuel cell is intensively carried out in the United States, Europe and Japan. Some have claimed to be able to produce fuel cells of 25 kW capacity at the cost of less than US$300/kW. This price is much reduced from those used in the space shuttle, which was US$500,000/kW.

Hydrogen is produced from sources such as natural gas, coal, gasoline, methanol, or biomass through the application of heat; from bacteria or algae through photosynthesis; or by using electricity or sunlight to split water into hydrogen and oxygen. The use of hydrogen as a fuel and energy carrier will require an infrastructure for safe and cost-effective hydrogen transport and storage. Hydrogen has an excellent safety record, and is as safe for transport, storage and use as many other fuels. Nevertheless, safety remains a top priority in all aspects of hydrogen energy. The hydrogen community addresses safety through stringent design and testing of storage and transport concepts, and by developing codes and standards for all types of hydrogen-related equipment.

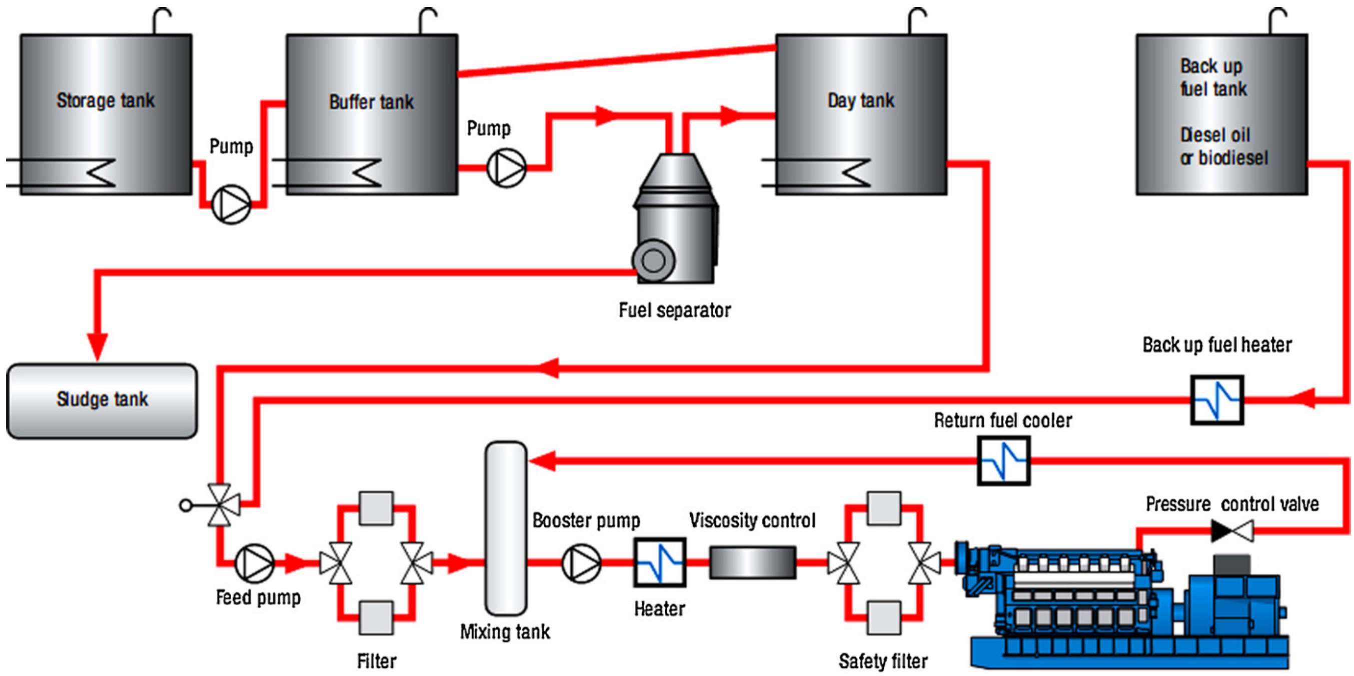

Fig. 11. Schematic diagram of a liquid biofuel power generation system.

The vision of building an energy infrastructure that uses hydrogen as an energy carrier – a concept called the "hydrogen economy" – is considered the most likely path toward a full commercial application of hydrogen energy technologies. Hydrogen is produced from available energy sources and used in every application where fossil fuels are being used in transportation, residential, commercial and industrial sectors and for electricity generation. The United States, Japan and many European countries have formulated strategies for long-term usage of hydrogen as energy carriers. Such concept has been proposed for many developing countries including Malaysia [14].

A large-scale solar hydrogen production in the Libyan desert and export hydrogen to Europe was also proposed [15]. The German-Saudi Arabian project HYSOLAR demonstrates the feasibility of this concept and provides useful information for the design and operation of solar hydrogen plant for the future [16]. Iceland has a plan of producing hydrogen for domestic use from renewable energy and will convert to full hydrogen economy by the year 2020. The first large scale hydrogen project in Iceland, announced in 2001 by the Ecological City Transport System was that 4% of the city's public transport would run hydrogen fuel cell buses. In addition, filling stations infrastructure and also electrolyzer facilities producing hydrogen from renewable would be provided. Already 70% of the primary energy sources in Iceland are from renewables mainly hydropower and geothermal [17].

4. Renewable energy mix in selected Islamic countries

4.1. Energy supply

The fuel mix in energy supply of most of the 39 selected Islamic countries is not yet well diversified. Coal and other clean renewable energy sources share very low percentages in total primary energy supply (TPES). Table 3 shows the contribution of renewable (with and without combustible renewable and waste) to TPES. All the relevant data were obtained and compiled from OECD/IEA [24,26a,b,f–h].

Bahrain, Kuwait, Oman, and Turkmenistan get their energy sources for TPES 100% from fossil fuels. The TPES per capita ranges from 0.3 to 20 toe/capita. Countries with TPES per capita higher than 10 toe/capita were Bahrain, Kuwait, Qatar and United Arab Emirates. Except Bahrain, these countries are OPEC members, the main exporters for petroleum products and had high dependency on fossil fuels as energy sources where energy from crude oil or/and natural gas shares more than 70% of the TPES. In contrast to countries that had very low TPES per capita (below 0.5 toe/capita) such as Benin, Mozambique and Togo, the main energy source for energy supply was combustible renewables and wastes. Mozambique had the highest renewable energy share of 94.7% in TPES from two sources, i.e. hydro and, combustible renewables and wastes in 2005. Among the renewable energy sources for TPES, combustible renewables and wastes are the dominant for most of the selected Islamic countries except for few. Azerbaijan, Kazakhstan, Kyrgyzstan, Syria, Tajikistan and Uzbekistan used hydro as their main renewable energy sources while in Jordan the main renewable energy sources for TPES are geothermal and solar.

Fig. 12 shows the energy per capita and the linkage with GDP per capita for some of the OIC countries [18]. It shows that the energy usage is tightly linked with the standard of living, where countries that have higher GDP per capita will have higher energy use per capita. Among them, Qatar as one of the OPEC members has the higher total primary energy supply per capita and hence ranks the first position.

4.2. Energy consumption

Petroleum products and natural gas were the dominant energy consumed. However, countries with total final consumption of energy (TFC) per capita below than 0.5, such as Cameroon, Cote d'lvoire, Mozambique, Sudan and Togo, were actually consuming energy from combustible renewables and wastes more than 65% of TFC. Combustible renewables and wastes are the major renewable energy sources in TFC for all almost the selected Islamic countries except Jordan, where the main RE sources are geothermal and solar that was about 96% of total RE in TFC. However, countries such as Bahrain, Kuwait, Oman, Tajikistan, Turkmenistan and Uzbekistan totally consumed energy from fossil fuel sources at end use stream. In 2005, countries such as Iraq, Nigeria and Uzbek-

Table 3
Share of renewables in TPES in 2005.

2005 countries	TPES (ktoe) from all types of fuels	TPES from fossil fuels (ktoe)	TPES from nuclear (ktoe)	TPES from RE (ktoe)	Share of total RE in TPES (%)	Share of main fuels % total RE		
						Hydro	Geotherm, solar, & other RE	Combust RE and waste
Albania	2370	1676	0	694	29.3	66.6	0.3	33.1
Algeria	34,761	34,637	0	124	0.4	38.7	0.0	61.3
Azerbaijan	13,732	13,468	0	264	1.9	98.1	0.0	1.5
Bahrain	8128	8128	0	0	0.0	–	–	–
Bangladesh	24,187	15,780	0	8407	34.8	1.3	0.0	98.7
Benin	2533	860	0	1673	66.0	0.0	0.0	99.9
Brunei Darus	2641	2623	0	18	0.7	0.0	0.0	100.0
Cameroon	6978	1156	0	5822	83.4	5.8	0.0	94.2
Cote d'Ivoire	7963	3269	0	4694	58.9	2.6	0.0	97.4
Egypt	61,368	58,797	0	2571	4.2	42.3	1.8	55.9
Gabon	1721	640	0	1081	62.8	6.5	0.0	93.5
Indonesia	179,512	121,816	0	57,696	32.1	1.6	9.8	88.6
Iran	162,563	160,392	0	2171	1.3	63.8	0.0	36.2
Iraq	30,760	30,569	0	191	0.6	23.6	0.0	13.6
Jordan	7093	6955	0	138	1.9	3.6	48.6	2.2
Kazakhstan	53,515	52,766	0	749	1.4	90.3	0.0	9.7
Kuwait	28,143	28,143	0	0	0.0	–	–	–
Kyrgyzstan	3029	1798	0	1231	40.6	99.6	0.0	0.3
Lebanon	5577	5313	0	264	4.7	34.1	3.4	48.1
Libya	19,047	18,892	0	155	0.8	0.0	0.0	99.4
Malaysia	61,279	57,994	0	3285	5.4	15.1	0.0	84.8
Morocco	13,813	13,153	0	660	4.8	18.6	2.7	68.2
Mozambique	10,415	553	0	9862	94.7	11.6	0.0	88.4
Nigeria	103,785	22,180	0	81,605	78.6	0.8	0.0	99.2
Oman	13,946	13,946	0	0	0.0	–	–	–
Pakistan	76,329	45,913	647	29,769	39.0	8.9	0.0	91.1
Qatar	15,826	15,825	0	1	0.0	0.0	0.0	100.0
Saudi Arabia	140,277	140,273	0	4	0.0	0.0	0.0	100.0
Senegal	3041	1789	0	1252	41.2	1.8	0.0	95.2
Sudan	18,398	3660	0	14,738	80.1	0.7	0.0	99.3
Syria	17,906	17,603	0	303	1.7	97.7	0.0	2.0
Tajikistan	3458	2002	0	1456	42.1	98.6	0.0	0.0
Togo	1995	362	0	1633	81.9	0.4	0.0	97.0
Tunisia	8451	7314	0	1137	13.5	1.1	0.4	98.6
Turkey	85,305	75,150	0	10,155	11.9	33.5	13.8	52.7
Turkmenistan	16,591	16,591	0	0	0.0	–	–	–
UAEmirates	46,936	46,920	0	16	0.0	0.0	0.0	100.0
Uzbekistan	47,047	46,520	0	527	1.1	100.0	0.0	0.0
Yemen	6728	6650	0	78	1.2	0.0	0.0	98.7

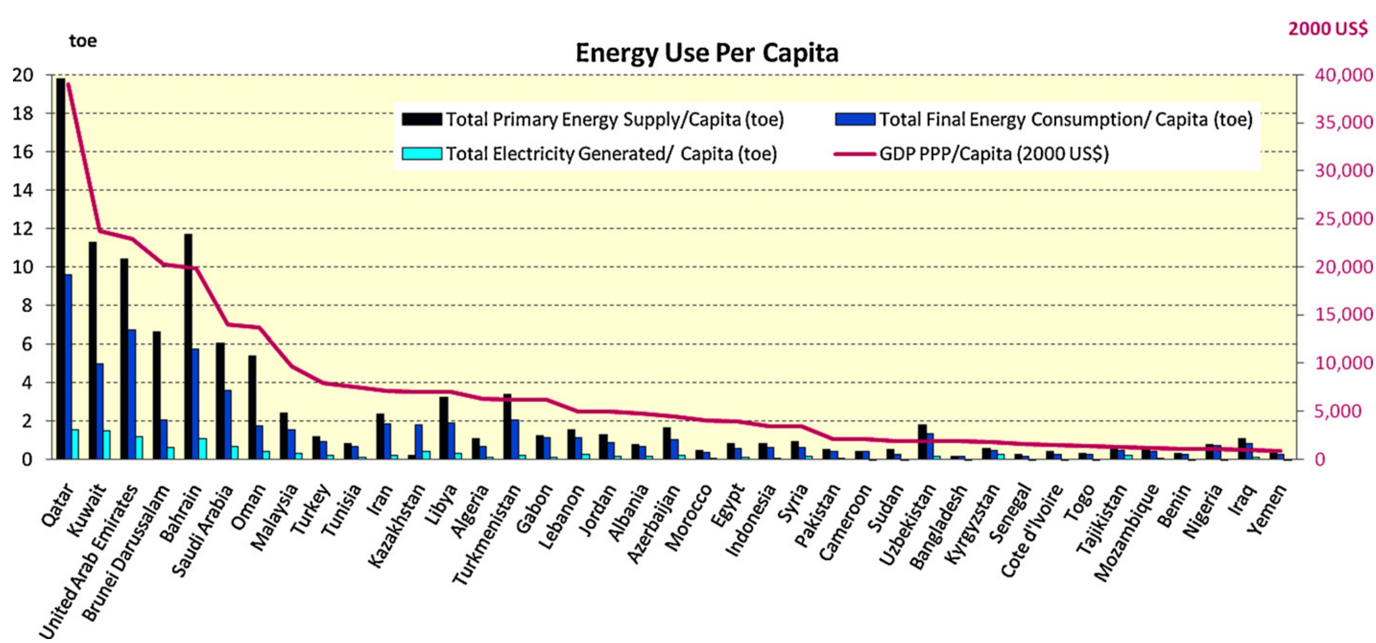

Fig. 12. Energy use per capita.

istan had shown relatively high final energy consumption per GDP, whereas Bangladesh and Tunisia had recorded final energy consumption per GDP less than 100 toe/million 2000 US$ PPP. These indicate that the former group of countries demands more energy for end users to produce 1 unit of final goods or services as compare to the latter group of countries. In term of electricity, Iraq, Kyrgyzstan and Tajikistan had relatively high final electricity consumption per GDP. Whereas countries that had per unit GDPPPP of final electricity consumption lower than 0.1 kWh/2000 US$ were countries that have electrification rate lower than 33%. Bangladesh is one of the nations with low coverage of electrification, hence lower final energy consumption per GDP. However, Tunisia and Algeria which also had relatively low value of per unit GDP of final energy and electricity consumptions have electricity coverage as high as 98–99%, indicating that they consumed energy more efficiently in socio-economic activities. In contrast, though Iraq is one of the largest energy exporters and has the longest depletion period of crude oil, it had recorded high value of per unit GDP of final energy and electricity consumptions which indicate poor energy efficiency in socio-economic activities.

4.3. Relationship between per capita energy consumption and income

The relationship between energy consumption per capita and income (GDP per capita) for some of the OIC countries in 2005 is as shown in Fig. 13. Most of the OIC countries were saturated in the area which has lower per capita energy consumption and GDP. Based on statistical analysis, it could to concluded that they are linked in linear relationship with the best approximate equation of $y = 0.225x$. Energy is needed for every single activity of economic development. This shows that approximately 0.225 toe of energy is required to earn USD1.0 in these countries.

4.4. Electricity generation and consumption

Table 4 shows that there are many people in some countries still have very low accessibility to electricity especially Mozambique (6%, 18.6 million) and Togo (17%, 5.1 million) [26f]. The energy sources for countries that have low electrification coverage are mainly combustible renewable and waste which might be traditional biomass such as charcoal, wood, straw, agricultural residues and dung. Inefficiently burned, biomass can be a major cause of indoor smoke pollution. The World Health Organization (WHO) estimated that, each year, 1.6 million women and children in developing countries are killed by the fumes from indoor biomass stoves [26i]. Albania, Cameroon, Mozambique and Tajikistan depended nearly 100% of renewable sources to generate electricity. On the other hand, countries that have electrification rate higher than 90%, 85–100% of the electricity was generated from fossil fuels. Bahrain, Brunei Darussalam, Kuwait, Libya, Oman, Qatar, Saudi Arabia and United Arab Emirates, which are also net energy exporters, generated electricity 100% from fossil fuels sources. In term of renewable energy in electricity generation, hydropower is the main energy source. Geothermal, solar, wind, tide, wave and other RE sources had also been utilized by Indonesia, Egypt, Morocco, Senegal and Tunisia for electricity generation.

5. Strategies for implementing renewable energy programs

The widespread application of renewable energy technology can be enhanced by employing several strategies namely (a) establishing education and capacity building programs (b) creating renewable energy market and financing mechanism (c) improving appropriate energy policies and (d) establishing database and international collaboration (e) enhancing industrial collaboration and R&D activities.

5.1. Educational and capacity building programs

Educational programs are able to provide the technical knowledge and improve the level of competency of service providers, engineers, architects, technicians and academia. Other capacity building programs can enhance the awareness level of the rationales for renewable energy technology among the public, policy makers, investors and financial institutions. Hence, the understanding of renewable energy technology would be raised to the point that they understand the technology, are aware of its true benefits and ecological significances understand the purpose and appreciate the functions of the technology. Educational programs on renewable energy should be implemented as part of the education agendas and well structured in all levels of education system. For instance renewable energy should be included as a chapter in science or physics subject at schools level, undergraduate and post-graduate programs at university level. Thus, the people would be provided with basic knowledge of renewable energy at primary and secondary levels and would have mastered the subject at tertiary level. Capacity building activities include programs such as seminars, workshops and short courses in renewable energy technology and policy. Key personnel especially engineers and architects would have the opportunities to understand and hence apply the technology in the economic sectors.

5.2. Renewable energy market and financing mechanism

The technical feasibility and economic viability of renewable energy technology can be addressed by implementing a number of demonstration projects. These projects will further provide a wider level of acceptance and better understanding of the technology and its benefits. The demonstration projects will also pave the way for providing first hand experiences for improvements in the training and skills of the stakeholders as well as increased efforts in R&D activities. The demonstration program must address adequate knowledge and experience to architects, engineers, project developers, policy makers and other stakeholders for subsequent follow-up program. Besides, several demonstration projects such as solar hot water heating system for hospitals, hotels and catering services should be implemented. Others include solar industrial process heat in the drying, food and textile industries. To initiate any renewable energy project, funders and investors play crucial roles in financing the project. Funders need to support infrastructure projects by providing loans to project developers. The government may provide soft grants, incentives and lower taxes to reduce the capital investment cost and hence encourage more renewable energy projects. Another financial aid is through the trade of carbon credit. Developing countries such as many members of the OIC are eligible to benefit through the Clean Development Mechanism (CDM) which allows industrialized countries with emission commitment to invest in emission reducing projects in developing countries. As shown in Fig. 14, renewable electricity projects are by far the most numerous in the CDM portfolio [19].

Apart from that, attracting the manufacturers to invest locally can reduce the cost of renewable energy technology components where import taxes would be avoided. In Malaysia, the future of solar energy technology is promising. Four manufacturers of solar modules have decided to locate their factories in Malaysia due to availability of educated workforce, attractive tax incentives and availability of silica oxide. They are First Solar, a manufacturer of solar modules from United States, German solar cell manufacturer Q-Cells AG, SunPower Corporation and Solarif Sdn Bhd [20].

Table 4
Electricity generation and consumption in 2005.

2005 countries	Electricity generation (GWh)[a] (% of total generation)							Electrification rate (%)[b]	Final electricity consump-tion/GDP PPP[a] (kWh/2000 US$)	Final electricity consump-tion/capita (kWh/capita)[a]
	Fossil fuels	Nuclear	Hydro	Geothermal	Solar, wind, tide, wave & others	Combust RE and waste	Total electricity generate			
Albania	70 (1.3%)	0 (0.0%)	5373 (98.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	5443 (100.0%)	NA	0.24	1163
Algeria	33,360 (98.4%)	0 (0.0%)	555 (1.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	33,915 (100.0%)	98	0.13	810
Azerbaijan	18,209 (85.8%)	0 (0.0%)	3009 (14.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	21,218 (100.0%)	NA	0.49	2174
Bahrain	8698 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	8698 (100.0%)	99	0.57	11,298
Bangladesh	21,350 (94.3%)	0 (0.0%)	1293 (5.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	22,643 (100.0%)	32	0.08	139
Benin	106 (99.1%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	107 (100.0%)	22	0.07	69
Brunei Darussalam	2913 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2913 (100.0%)	99	0.33	6687
Cameroon	232 (5.6%)	0 (0.0%)	3913 (94.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	4145 (100.0%)	NA	0.10	214
Cote d'Ivoire	4133 (74.2%)	0 (0.0%)	1437 (25.8%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	5570 (100.0%)	50	0.11	166
Egypt	95,494 (87.9%)	0 (0.0%)	12,644 (11.6%)	0 (0.0%)	552 (0.5%)	0 (0.0%)	108,690 (100.0%)	98	0.31	1183
Gabon	748 (47.7%)	0 (0.0%)	814 (51.9%)	0 (0.0%)	0 (0.0%)	7 (0.4%)	1569 (100.0%)	48	0.14	831
Indonesia	109,999 (86.4%)	0 (0.0%)	10,759 (8.4%)	6604 (5.2%)	0 (0.0%)	0 (0.0%)	127,362 (100.0%)	54	0.14	485
Iran	164,290 (91.1%)	0 (0.0%)	16,100 (8.9%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	180,390 (100.0%)	97	0.28	2006
Iraq	33,481 (98.5%)	0 (0.0%)	519 (1.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	34,000 (100.0%)	NA	1.27	1155
Jordan	9591 (99.4%)	0 (0.0%)	57 (0.6%)	0 (0.0%)	3 (0.0%)	0 (0.0%)	9651 (100.0%)	100	0.31	1522
Kazakhstan	60,060 (88.4%)	0 (0.0%)	7856 (11.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	67,916 (100.0%)	NA	0.06	408
Kuwait	43,734 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	43,734 (100.0%)	100	0.46	10,932
Kyrgyzstan	60,060 (88.4%)	0 (0.0%)	7856 (11.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	67,916 (100.0%)	NA	1.06	1824
Lebanon	9078 (89.7%)	0 (0.0%)	1046 (10.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	10,124 (100.0%)	100	0.50	2488
Libya	22,500 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	22,500 (100.0%)	97	0.41	2858
Malaysia	81,522 (93.4%)	0 (0.0%)	5784 (6.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	87,306 (100.0%)	98	0.33	3190
Morocco	21,012 (92.8%)	0 (0.0%)	1426 (6.3%)	0 (0.0%)	206 (0.9%)	0 (0.0%)	22,644 (100.0%)	85	0.14	585

Table 4 (*Continued*)

2005 countries	Electricity generation (GWh)[a] (% of total generation)							Electrification rate (%)[b]	Final electricity consump-tion/GDP PPP[a] (kWh/2000 US$)	Final electricity consump-tion/capita (kWh/capita)[a]
	Fossil fuels	Nuclear	Hydro	Geothermal	Solar, wind, tide, wave & others	Combust RE and waste	Total electricity generate			
Mozambique	21 (0.2%)	0 (0.0%)	13,264 (99.8%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	13,285 (100.0%)	6	0.42	464
Nigeria	15,588 (66.2%)	0 (0.0%)	7951 (33.8%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	23,539 (100.0%)	46	0.13	132
Oman	12,648 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	12,648 (100.0%)	96	0.25	3400
Pakistan	60,486 (64.5%)	2484 (2.6%)	30,862 (32.9%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	93,832 (100.0%)	54	0.21	434
Qatar	14,396 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	14,396 (100.0%)	71	0.39	15,119
Saudi Arabia	176,124 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	176,124 (100.0%)	97	0.42	5845
Senegal	2081 (81.8%)	0 (0.0%)	267 (10.5%)	0 (0.0%)	145 (5.7%)	51 (2.0%)	2544 (100.0%)	33	0.09	149
Sudan	2885 (70.0%)	0 (0.0%)	1239 (30.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	4124 (100.0%)	30	0.05	96
Syria	31,490 (90.1%)	0 (0.0%)	3445 (9.9%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	34,935 (100.0%)	90	0.35	1194
Tajikistan	401 (2.3%)	0 (0.0%)	16,685 (97.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	17,086 (100.0%)	NA	1.88	2254
Togo	113 (60.4%)	0 (0.0%)	74 (39.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	187 (100.0%)	17	0.07	95
Tunisia	13,468 (98.6%)	0 (0.0%)	145 (1.1%)	0 (0.0%)	42 (0.3%)	0 (0.0%)	13,655 (100.0%)	99	0.15	1128
Turkey	122,120 (75.4%)	0 (0.0)	39,561 (24.4)	94 (0.1%)	59 (0.0%)	122 (0.1%)	161,956 (100%)	NA	2.27	1786
Turkmenistan	12,817 (100.0%)	0 (0.0%)	3 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	12,820 (100.0%)	NA	3.86	23,938
U.A. Emirates	60,698 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	60,698 (100.0%)	92	0.52	11,966
Uzbekistan	41,580 (87.2%)	0 (0.0%)	6127 (12.8%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	47,707 (100.0%)	NA	0.82	1500
Yemen	4741 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	4741 (100.0%)	36	0.19	155

NA = not available.

[a] Data compiled from OECD/IEA 2007.

[b] Data compiled from OECD/IEA 2006.

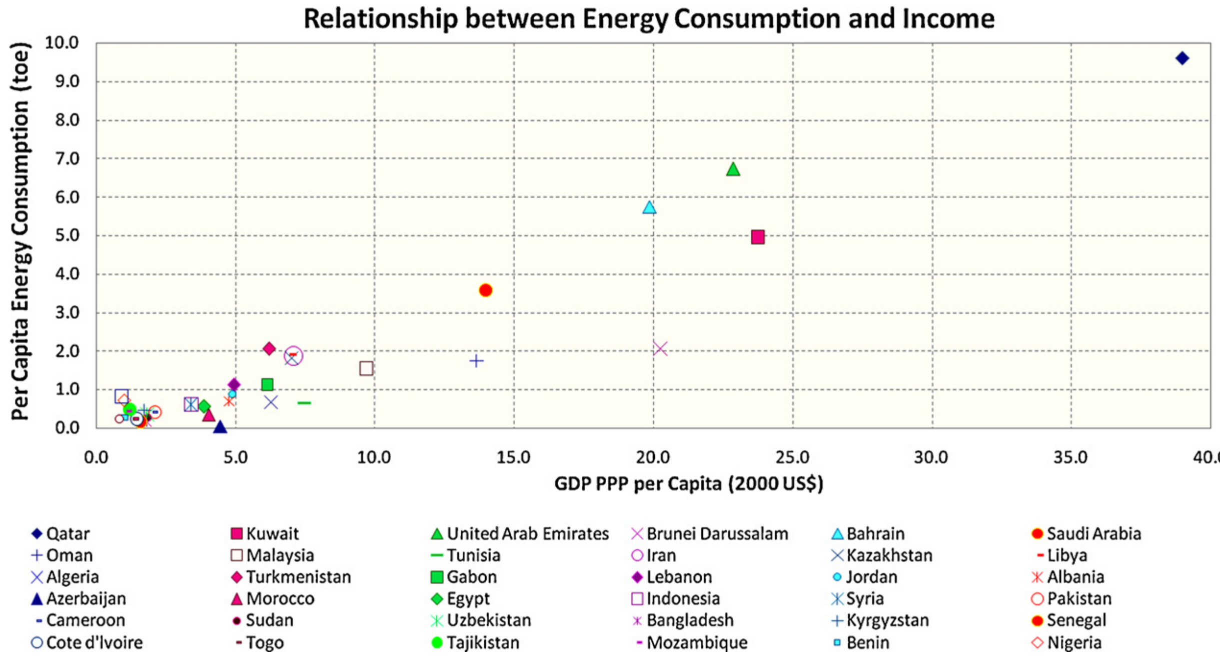

Fig. 13. Relationship between per capita energy consumption and income.

These investments will create job opportunities for the local people and would help in economic growth. There will be demand for more human resource capacity in R&D and manufacturing. Partnership and/or joint ventures with international companies will upgrade local companies. R&D institutions and the technical infrastructure for testing and certification facilities will be established to ensure only high quality commercial renewable energy products are produced for the local and international markets. Therefore, investment taxes and incentives strategy need to be well formulated to attract more international manufacturers and encourage local industries utilizing the renewable energy technology.

The outcome of these strategies will strengthen the industry, consumers and policy/decision makers. These will ensure the increase of renewable technology installed capacity and the long-term cost reduction of the technology via the increase in demand, economies of scale and competitive local manufacturing.

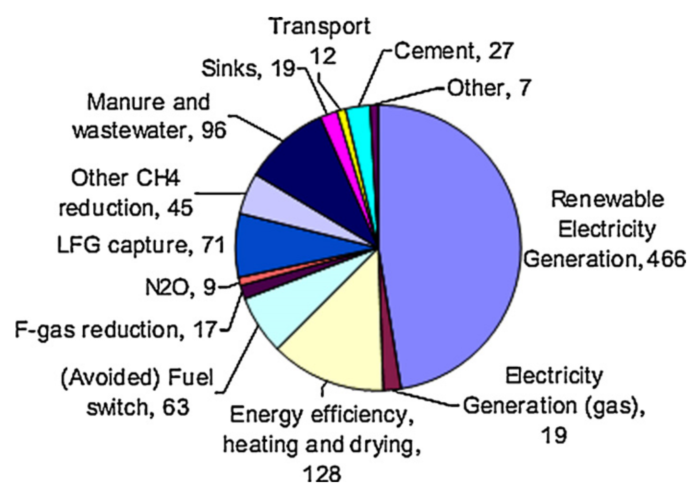

Fig. 14. Number of projects by type, April 2006.

5.3. Renewable energy policy

Appropriate, proactive and integrated plans and policies will facilitate the development of conducive business environments and thus enhancing further cost reduction of the renewable technology. A good renewable energy policy involves comprehensive studies to formulate appropriate, effective and financially efficient and bankable action plans.

Thus, a compilation of policy, legal, institutional, financial and fiscal measures could be proposed to the respective governments. Studies such as potential of implementing the renewable energy in the country could be proposed as national targets to be achieved in a given period. Achievable targets are important to create confidence and hence encourage more renewable energy projects in the subsequent development plans.

A Feed-in Tariff (FiT) or Feed-in Law (FiL), renewable energy payment or solar premium, is a proven incentive structure to encourage the adoption of renewable energy through government legislation. The regional or national electricity utilities are obligated to buy renewable electricity at above market rates set by the government. The higher price helps overcome the cost disadvantages of renewable energy sources. The rate may differ among various forms of renewable energy power generation.

Schemes such as quota incentive structures (renewable energy standards or renewable portfolio standards) and subsidies create limited protected markets for renewable energy. The supply of renewable energy is achieved by obliging suppliers to deliver to consumers a portion of their electricity from renewable energy sources. In order to do this they collect green electricity certificates. Hence a market is created in green electricity certificates, which according to the theory, generate downward pressure on the prices paid to renewable energy developers. This is based on the theory of perfect competition where there is a multiplicity of buyers and sellers in a market where no single buyer or seller has a big enough market share to have a significant influence on prices. Although, in practice, markets are very rarely perfectly competitive, the assumption is still that a relatively competitive market will produce a more efficient use of resources compared to a system where prices are set by Government fiat.

The fundamental problem with the quota scheme is that there is no long-term certainty. When a quota is set either for a period

of time or for a quantity of power, once that goal is reached then there is nothing to keep the green power producers from becoming uneconomic in the face of power produced from coal fired power stations and hence collapsing as businesses. This inevitability with the quota method means that there is reluctance on behalf of investors to get involved in the first place. Those that do get involved are short-term speculators rather than long-term entrepreneurs and so instability is inherent in this system.

It has been argued that FiT is the most effective way to promote the uptake of renewable energy yet devised. After investment subsidies it is the most widespread means of promoting renewable energy uptake in Europe. A very good example is Germany where FiT has successfully created over 300,000 direct employments and created over 200 companies related to solar energy. Malaysia will table the draft feed-in-tariff program to the Parliament in October is looking forward to implement it in June 2011.

As discussed above, apart from financial aides, enforcement could be one of the options for enhancing renewable energy market. Government could introduce Mandatory Renewable Generation Targets as legislated requirement on electricity retailers to source specific proportions of total electricity sales from renewable energy sources according to a fixed timeframe. This approach allows electricity purchasers to acquire a certain amount of renewable power from the utilities and could be penalized if they fail to do so. Table 5 shows the renewable energy targets for some of selected OIC countries. All the relevant data were obtained and compiled from [21–23,26j–t]

Table 5
Renewable energy targets for some of selected Islamic countries.

Country	Target(s)
Albania	Biomass 9.517 Mtoe by year 2050, Wind power 400 GWh/year by year 2020, Solar energy potential 125 MWth of installed capacity, hydropower potential of annual generation is 10 TWh, Energy saving 22.48% of the total energy consumption by 2015 (forecasted at 118 PJ)
Algeria	150-MW CSP plant planned for 2012, with grand plans of exporting up to 6 gigawatts (GW) of solar power to southern Europe by 2020
Bangladesh	Policy sets targets for developing renewable energy resources to meet 5% of the total power demand by 2015 and 10% by 2020
Egypt	20% share of renewable energy in electricity generation by 2020
Indonesia	>5% biofuels, >10% other new & renewable by 2010; 50–60% and 60–70% share of renewable energy in electricity generation by 2030 and 2050, respectively
Iran	500 MW of electricity output by 2010; 25–30% and 60–70% share of renewable energy in electricity generation by 2030 and 2050, respectively
Jordan	By 2015, 5% of the total energy mix will come from renewable energy resources (a wind park with a capacity of 75–100 MW. A Hybrid Solar Power Plant (CSP) with a capacity of 100–150 MW)
Lebanon	10% of the country's energy needs are covered by the year 2015 by renewable energy sources
Libya	10 MWp From PV, 150 MW from Wind, 20,000 m^3 from thermal water heating, 20 MW from thermal electricity, 20,000 m^3 from thermal desalination, 20 kW from hydrogen by 2020
Malaysia	Add 350 MW renewable energy generation capacity by 2010. Introduction of feed-in-tariff programme in 2011
Morocco	1 GW wind power by 2012 and 400,000 square meters solar hot water added by 2015; 20% share of renewable energy in electricity generation by 2012
Nigeria	7% share of renewable energy in electricity generation by 2025
Pakistan	Minimum of 9700 MW by 2030 as per the Medium Term Development Framework (MTDF) [includes the following technologies: small hydro of 50 MW or less capacity, Solar photovoltaic (PV) and thermal energy for power generation, Wind power generation]; 10% share of renewable energy in electricity generation by 2015
Saudi Arabia	Min 15% by 205
Tunisia	500,000 square meters solar hot water by 2009 and 300 MW added wind by 2011
Turkey	2% of electricity from wind by 2010
Uganda	To increase the use of modern renewable energy, from the current 4–61% of the total energy consumption by the year 2017 (100 MW small hydro and 45 GW geothermal by 2017; other rural electricity and productive-uses targets)
Uzbekistan	To expand renewable energy use up to 1–2.5% by 2005–2010

5.4. Institutional and international collaboration within OIC countries

Institutional and collaboration in education, research and development and information services are important for human development, capacity building and data gathering. Database for energy data and statistics could be established to have better monitoring and assessment on the progress of renewable technology implementation.

Centers of excellent for a particular renewable technology should be established to take up the leading responsibility to share the knowledge, provide training and consultancy services to the members.

For instance, Solar Energy Research Institute (SERI) of Universiti Kebangsaan Malaysia which has been recognized by the Islamic Scientific, Education and Cultural Organization (ISESCO) as the Islamic International Centre for Solar Energy Training, Research and Application (ICETRA), has taken up the responsibility to host some of the training programs and workshops on renewable energy. The target groups of the workshops ware local policy makers and key personnel from the selected OIC countries.

Other centers of excellence that should be established are (a) centers of excellence for wind energy conversion (b) centers of excellence for renewable hydrogen and fuel cell (c) centers of excellence for biomass (d) centers of excellence for marine base energy and (e) centers of excellence for hydropower.

5.5. Enhancing industrial collaboration and R&D activities

There is no doubt that collaborative R&D has made and will continue to make important contributions to the technological and economic well-being of Islamic countries. But in considering the roles and contributions of collaboration, the Islamic countries must focus on the objectives of collaborative programs, rather than treating R&D collaboration as a "good thing" in and of itself. Collaborative R&D can yield positive payoffs, but it is not without risks. Moreover, R&D collaboration covers a diverse array programs, projects, and institutional actors. No single recipe for project design, program policies, or evaluation applies to all of these disparate entities.

A brief discussion of the potential benefits and risks of R&D collaboration is useful to assess the design and implementation of specific collaborative programs. The economics literature identifies three broad classes of benefits from R&D collaboration among industrial firms: (1) enabling member firms to capture "knowledge spillovers" that otherwise are lost to the firm investing in the R&D that gives rise to them, (2) reducing duplication among member firms' R&D investments, and (3) supporting the exploitation of scale economies in R&D. This group of (theoretical) benefits has been supplemented by others in more recent discussions of policy that often address other forms of collaboration: (1) accelerating the commercialization of new technologies, (2) facilitating and accelerating the transfer of research results from universities or public laboratories to industry, (3) supporting access by industrial firms to the R&D capabilities of federal research facilities, and (4) supporting the creation of a common technological "vision" within an industry that can guide R&D and related investments by public and private entities.

Table 6
Business potentials in renewable energy in OIC countries.

Technologies	Development potential in OIC countries MWe/year	Manufacturing & potential	Technical services & consultancy	EPC	R&D capabilities	Project finance
Solar thermal	200	High	High	Medium	High	High
Solar PV	500	High	High	Medium	High	Medium
Wind	300	Medium	High	Medium	High	Low
Biomass	100	High	High	High	High	Medium
Bio-fuels		High	High	High	High	Medium
Micro-hydro & pico-hydro	1	High	High	High	High	High
Wave & tidal	1	Low	Low	Low	High	Low
Biogas	10	High	High	High	High	High
Waste-to-energy systems	30	High	High	High	High	Medium
Geothermal	200	Low	Low	Low	Low	Low

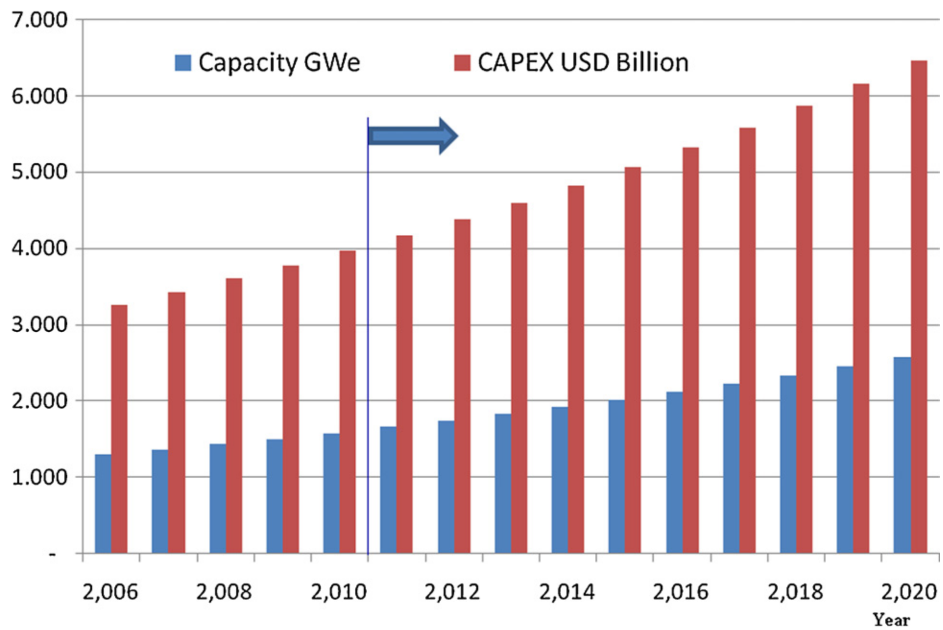

Fig. 15. Projected growth of renewable energy projects (MWe) and estimates of capital expenditure (bil USD) in OIC countries for 2010–2020.

5.6. Renewable energy industry in OIC countries

The potential of creating a vibrant renewable energy industry in the OIC countries is great as summarized in Table 6. There are ample opportunities for large project finance opened to richer GCC countries. There are many capable technical expertise for engineering and consultancy services in some member countries. Malaysia, Pakistan, Iran, some GCC countries have the capabilities to manufacture components of solar PV and solar thermal technologies. Research and development capabilities exist in many countries such as Malaysia, Saudi Arabia, Pakistan, Iran, Egypt, Turkey, Indonesia and many others.

The success of these activities relies very much on the availability of sufficient and adequate funds. It is estimated that approximately 1250 MW of renewable energy is required per year for economic growth in member countries for the next 5 years (2011–2015). The projected annual capital expenditure in billion USD until 2020 is summarized in Fig. 15. The growth rate is expected to be about 20% per year.

- Renewable energy technologies have become a global market worth US$650 billion in 2008 and is predicted to exceed USD2300 billion by 2020 [25].
- The United States, Japan and the European Union as the leaders. China is aggressively penetrating the market.

6. Conclusions

This study reveals the following conclusions:

(1) Some members of the OIC countries are blessed with the wealth of crude oil and gas. The oil and gas industry in these countries has contributed tremendously to the development of their respective countries as reflected in the high values of GDPPPP. Therefore the implementation of renewable energy programs in these countries are very limited indeed.
(2) The countries with very much lower GDPPP have to import crude oil and petroleum products. However, the use of renewable energy resources such as biomass, biogas, hydro, solar photovoltaic and solar thermal, wind, tidal and waves, and geothermal is still not fully exploited. Perhaps fire wood accounts for greater use of renewable energy in poorer countries.
(3) Mozambique and Togo depended highly on combustible renewables and wastes, and had very low electrification rate. Mozambique had the highest renewable energy share of 94.7% in TPES from hydro and combustible renewables and wastes.

(4) Azerbaijan, Kazakhstan, Kyrgyzstan, Syria, Tajikistan and Uzbekistan relied on hydro as renewable source of energy.
(5) Geothermal, solar, wind, tide, and wave had also been utilized by Indonesia, Egypt, Morocco, Senegal and Tunisia for electricity generation.
(6) Albania, Cameroon, Mozambique and Tajikistan rely more than 95% of their electricity generation from renewable energy resources, mainly hydro.
(7) Bahrain, Brunei Darussalam, Kuwait, Libya, Oman, Qatar, Saudi Arabia, Turkmenistan and United Arab Emirates, which are also net energy exporters, generated electricity 100% from fossil fuels sources.
(8) Countries that had per unit GDPPPP of final electricity consumption lower than 0.1 kWh/2000 US$ had electrification rate lower than 33%.
(9) Although some countries were able to generate energy for export, yet they were not able to supply electricity to all areas especially the remote areas due to insufficient transmission and distribution infrastructure, causing groups of population there being deprived of modern energy services.
(10) The FiT is a mechanism that allows electricity that is produced from indigenous RE resources to be sold to power utilities at a fixed premium price and for specific duration. It provides a conducive and secured investment environment which will make financial institutions to be comfortable in providing loan with longer period (>15 years) and hence provides fixed revenue stream for installed system. Only pays for electricity produced: promotes system owner to install good quality and maintain the system. With suitable degression rate, manufacturers and installers are promoted to reduce prices while enhancing quality.
(11) Long term strategies have to be adopted to promote renewable energy technologies especially namely
   (a) Establishing education and capacity building programs
   (b) Creating renewable energy market and financing mechanism
   (c) Improving appropriate energy policies and
   (d) Establishing database and international collaboration
   (e) Enhancing industrial collaboration and R&D activities.

   The outcome of these strategies will strengthen the industry, consumers, R&D activities and policy/decision makers.
(12) A timeline has been developed as a guideline for implementation of the strategies and can be modified depending on the needs and urgency of the applications ofsuitable renewable energy technologies in the OIC countries.

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